Lecture 2 Columbia University. April 8, 1964

Chromosome Organization and Function in Higher Organisms.

I. A view of differences in the organization of chromosomes in higher organisms
   Appearances of chromosomes at the pachytene stage of meiosis:

Slide 1. The 10 bivalents in maize: Morgan photo. Nucleolus; nucleolus organizing chromosome(small knob). Chr.7 with knob. chr. 5. knob; chr. 9 knob. Chromomere near end of short arm of chr. 4. Chr. 3 chromomere. Chr. 6 chromomere. Centromeres.

Heavily staining regions near centromeres: Contain genes.

Slide 2. The nucleolus chromosome maize: Knob (b) position; The fused knobs.

Slide 3. The 10 chromosomes of Sorhgum - relative of maize: The deep staining regions near centromeres; The ghost parts towards ends. Centromeres.

Slide 4. Bermuda grass: The chromomeres; the deepstaining regions(heavy chromomeres); the terminal knobs.

Slide 5. Tomato chromosomes: Deep chromomeres near centromeres; the ghost regions. Nucleolus chromosome: position of centromere.

Slide 6. Antirrhinum (snapdragon). Heavy chromomeres; terminal knobs.

Slide 7. Luzula. Chromomere organization; terminal knobs.

Slide 8. Luzula.

Slide 9. Salvia glutinosa: Chromomere organization.

Slide 10. Salvia horminum: The large chromomeres near centromeres.

Slides 11. to 14. Neurospora - Fungus; Meiosis - 50x longer than somatic chromosomes; tremendous growth in meiotic prophase.

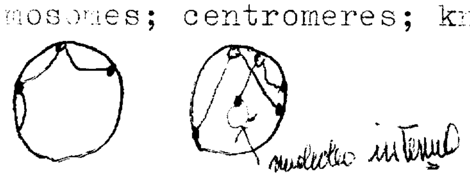
Slide 11: nucleolus chromosome.
Slide 12: Chromosome 3
Slide 13: Chr. 6 - "knobs"
Slide 14: chr. 1- heterochromatin

Slide 15: Cyclops (copepod). Germ line cell - prophases. Ends - heterochromatin.

Slide 16: Cyclops - diplotene;

Slide 17: Somatic prophase of Rye chromosomes. The terminal knobs.

II. The position of the chromosomes in the somatic and meiotic nuclei:
   Ends of chromosomes; centromeres; knobs: At the nuclear membrane!!



III. The knobs: Present in a large number of organisms: those with a general chromomere pattern with no distinct "heterochromatin" type organization near centromeres.

1. Knobs examined in detail only in maize; other organizams with knobs not so examined.

2. Knobs in maize: can be very varied: depends on the race of maize.

3. The knob-forming regions in each of the ten chromosomes of maize: Slide 18.

(a). The variation of knobs at any one position: Slide 19 (Morgan photo)

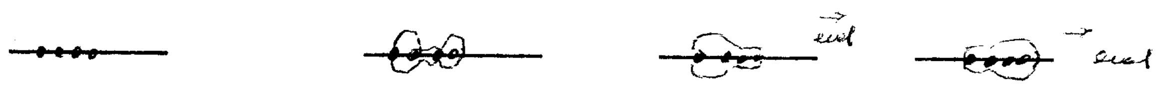
(1) Knobs - 9; 7, 5; small knob 6-a.
No knobs - 10, 8, 4, 3, 2, 1.

(2). Medium knob, homozygous; chr. 5. Slides 20, 21
Medium-large knob; chr. 5. Slide 22   Large knob, chr. 2.

(3). Chromosome 9: No knob, small knob, medium knob; large knob: Slides 23, 24, 25.

(4). Heterozygous knobs: Slides 26 and 27. inheritance of knobs

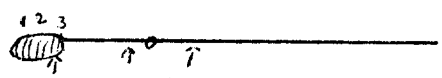
4. The mode of action of the knob-forming regions: Controls of size and shape:



Example: Slide 28 - chr. 4

5. The proof of the knob-forming regions: X-rays: cut into two parts:

Knob, short arm of chromosome 9: Rearranged chromo. 9.



Redundancy

Constancy in generation after generation.

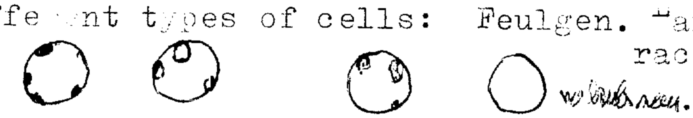
6 ~~IV~~. The races of maize and their chromosome differences. The Americas.

1. Differences among ears of the races: Slides 29, 30, 31. Small Ear

2. Knob constitutions: Central America; West coast of Mexico: Very large knobs at nearly all knob forming regions.

3. The Abnormal chromosome 10: In Western Mexico: Slide 32

7 ~~V~~. The constitution of knobs in different types of cells: Feulgen. Large knob race.
Relation to nuclear membrane.



Size of nuclei
" in somatic cells

8 ~~VI~~. Conclusions on knobs: Not a constant of genotype; regions show specific genetic differences among races; inherited differences; redundancy of parts; changes in constitution in different types of cells.

Need for further cytochemical studies.

General prevalence of knobs in organizms with particular type of chromosome organization.

No knob vs. many large knobs: no differences in the plants; No known effects in the hybrids.

Redundancy:

IV. Nucleolus organizers: The organizers in maize: different sizes. Different positions where nucleolus is organized at most rapid rate.

1. The redundancy in the nucleolus organizer:

   (a). The maize case -- already examined. Diagram break and action. (was reversed - Brown)

   (b). Chirmomous: similar to maize - breaks

   (c) Drosophila melanogaster and buskii - same as maize.

2. The need for the nucleolus: Assembly plant for ribosomes (RNA from genes in chromosomes). Methylation of transper RNA. (considered by Moore)

3. Absence of nucleolus organizer - no nucleolus - many small nucleolus-like bodies; The genetic effect in Chironomous and Xenopus.

V. The centromeres: Redundancy. Divisions into two parts - several organisms Same result as in maize; different parts function.

VI. The significance of redundancy:

1. Shown in the knobs of maize
2. Shown in the nucleolus organizers
3. Shown in the ever present polyploidy in many organisms - especially recognized in plants. Some organisms with very great degree of redundancy of chromosome sets.
4. Two major aspects of this: Safty measure - when something happens to major active part, other parts take over;
   Required for effective gene action - as will be clear shortly.

Part II. Regulation of gene action. Structural level.

I. Regulation of level of gene action through redundancy of genes: within different cells of the same organisms.

1. Increase in whole sets of chromosomes in different nuclei of same organism: Methods

   (a). Polyploid nuclei - increase in sets; chromosomes separated.
   (b) Polyteny - Replication of chromosomes; remain together: Salivary gland type.
   (c) Combination of this: Some sells of the cecidomyids.

2. Increases in single chromosomes of the set:

   salivaries & "sex-ratio"

   (a). X chromosome in Drosophila males: XX females vx. XY males.

   (b) Single chromosome in Salivaries - Cecidomyid: Slide 33

3. Increases in parts of chromosomes: Drosophila X chromosome:

   Ganglia cells: ratio DNA: Euchromatin 2 : 1 heterochromatin
   Salivaries " " " 50 : 1 "

4. Increase in single bands (genes) in salivaries just before gene becomes active: Rhyncosciara; Drosophila. Somatic cells only

II. Regulation of level of gene action through reduction in gene potentials.

1. Control of gene action through loss of whole sets -- males. Many insect forms.
2. Control of gene action through loss of individual chromosomes - Examples given in X chromosome of Sciara.
3. Control of gene action through loss of heterochromatic parts of chromosomes in the soma but not the germ line: Many examples of this in insects.

III. Regulation in plants and animals: Animals with their soma which dies has experimented with gene control in many different ways, some described above.

Plants: regeneration of parts occurs from somatic cells; regulation is more conservative. Cannot lose parts, increase of genes by reduplication of gene itself; Must have other method of control of gene action.

IV. The regulation of gene action through structural modifications within the nucleus.

1. Level of the gene: Removal of the histon - protein associated with DNA in order that gene be transcribed.
2. Control of gene action through condensation of the chromosome parts:

   Levels: Complete condensation - metaphase chromosome type: No RNA produced by metaphse condensed chromosome.

   Partial condensations - smaller parts of chromosomes.
3. Complete condensations:
   (a) Whole set of chromosomes : Coccid: Slide 34. Male set.
   (b) X chromosomes in mammals: Reviewed previously.
   (c) Position of condensed chromosomes: at the nuclear membrane.
4. Partial condensations: Differences in different cells of plants and animals. Same type always found in same type of cell.
   (a). Very active cells: Large nucleolus; chromosomes not condensed; finely granular within the nucleus.
   (b) Nuclei with low gene action: small nucleoli; highly granular chromatin, much of this at nuclear membrane. Small nuclei, in general.
5. Examples of differential condensation:
   (a). Retina cells in 10 day old kitten. Slides 35 and 36.
   (b). Lymphocytes: Slides 37 and 38. Position of condensed chromatin.

V. Summary.

RNA production: 14% in condensed parts = 70% of
Fractionation after new RNA product - 80% of DNA in condensed chromatin = contains 17% RNA and only 14% newly produced RNA
genes in condensed portion of DNA = inactive

Slides - lecture 2

1. 10 bivalents in maize - Metaphase -
2. Chr-6. in maize
3. Sorghum - 10 chro.
4. Bermuda grass.
5 Tomato chromosomes.
6. Antirrhinum -
7+8 Luzula
9. Salvia glutinosa
10. Salvia horminum
11 to 14 Nemophila.
15. Cyclops - copepod - germ line cells
16 " Diplotene
17 Pyg-Somatic chromosomes - Terminal bands.
18 - Diptera. Knob forming regions.
19 - 10 bivalents in maize - (Metaphase plate) - knobs
20-21 Chr 5 - medium knob chr. 5. Large knob. Chr. 2
23-25. Knob, end of chr 9 short arm.
26-27 Heterozygous knobs.
28. Chr 4 knob - shape.
29-31 Ears of maize appearance.
32. Abnormal chr. 10
33. Cecidomyzid salivaries.
34. Mealy-bug: whole set of chr - heterochromatic
35-36 . Retina cells of cattle - nucleus
37-38 cap Lymphocytes - heterochromatin.